Specialty Conference

Computers in Medicine—The Office Setting

Discussant, MARC GELMAN, MD

This discussion was selected from the weekly Grand Rounds in the Department of Medicine, University of New Mexico School of Medicine.

RALPH C. WILLIAMS, Jr, MD:* In this conference Dr Marc Gelman, one of our residents most familiar with computers and their capabilities, will discuss an important subject—computers in medical practice. This topic should be of increasing interest to all of us.

MARC GELMAN, MD:†‡ Computers in the office setting deserve special attention because they represent an issue that affects many physicians who wish to purchase and use computers. It is of increasing importance, as evidenced by the numerous seminars attracting physicians and their money. Though I will be describing the merits of using computers in small group practices consisting of three to seven physicians, their wider applications will be self-evident. My purpose is to present what computers are capable of doing in an office setting today, portray future trends and concepts for computerization, including ethical and risk management considerations, and, last, offer thoughtful considerations and caveats toward the purchase of a computer. For purposes of orientation, a glossary of computer terminology is presented in Table 1.

Although a large number of articles addressing computers in medicine are cited in the *Index Medicus,* few references are listed that discuss their applications in the small group practice setting, presumably reflecting not only the infancy of computer use in clinical medicine but physician xenophobia as well. The information I have assembled, therefore, relies heavily on that supplied by computer vendors and personal observations.

I investigated what was commercially available from local vendors who sell software designed to operate on machines marketed by such manufacturers as Digital, International Business Machines (IBM), National Cash Register, Radio Shack and Texas Instruments. Common attributes of many of the systems are summarized in Table 2. Accessories to the basic system could provide such features as storage of brief narratives describing the patient-physician visit, custom designing of financial reports, variation of the billing cycle (determines when patients receive their bill), generation of bank deposit slips, collection letters for overdue payments, billing for hospital-based patients, lists of patients admitted to hospital and their bed assignments and appointment scheduling subdivided into five-minute blocks of time.

The microcomputer and minicomputer systems that I reviewed required only moderate training to achieve competence. The operating instructions were typically simplified by providing "menus" on the video screen that carefully detailed options to be selected at each step of the user-computer interaction. Systems cost between $8,000 and $150,000. The variation in cost was a function of the size of computer, memory, sophistication of software, number of terminals and after-sales support.

It was difficult to examine the differences between computerized and manual bookkeeping records in simple dollars and cents.[1] An example of one manual system is the pegboard, costing about $350 for a starter kit that is sufficient to maintain the needs of a single physician for one year. This system accommodates the activities of three to four physicians and generates a superbill. Insurance forms are avoided by requesting direct patient payment. The added value, however, of a computer limited to the group practice setting is realized in (1) decreasing the need for additional front office help as the practice grows; (2) simplifying and expediting billing to third-party payers; (3) helping to recognize procedures not economically viable; (4) improving the allocation of physicians' time; (5) aiding in preparing tax forms; (6) providing word processing, and (7) performing personal computing tasks. In addition, the actual cost of the computer is mitigated by the favorable tax treatment it receives in terms of investment tax credits and depreciation.

Though computers can improve front office efficiency, their role in electronic medical charting is much more provocative. Whereas a number of commercial systems is available, there is sparse literature describing meaningful experiences in the clinical environment. Two documented systems are described below.

The first system, situated in Hawaii, addressed front office functions and aspects of the back office.[2] The system, used in 1978 by a family practice group, provided an ongoing com-

*Professor and Chair, Department of Medicine, University of New Mexico School of Medicine.

†Resident, Department of Medicine, University of New Mexico School of Medicine.

‡Important suggestions and criticisms were made during the preparation of this conference by Fred Hashimoto, MD, Associate Professor of Medicine, Department of Medicine, University of New Mexico, Albuquerque.

(Gelman M, Williams RC: Computers in medicine—The office setting—University of New Mexico School of Medicine [Specialty Conference]. West J Med 1985 Feb; 142:230-234)

Reprint requests to Marc Gelman, MD, Department of Internal Medicine, University of New Mexico, 2211 Lomas Blvd NE, Albuquerque, NM 87106.

TABLE 1.—*Glossary of Computer Terminology*

back office Physical area staffed by physicians carrying out activities such as history taking and physical examinations that become part of the medical record

byte A byte (one character) is less than a word; 10 words = 1 line of programming

computer A machine that is capable of interpreting a sequence of instructions and delegating chores to such accessories as printers, video screens and memory devices

CPU Central processing unit: the brain in the computer. The speed with which the CPU can process information depends on a number of factors:
- the rate (defined in megahertz) of information stored in memory devices that can be called up;
- the size of words that can be read and processed at any one time: 8 bit-8 bit, 8 bit-16 bit, 16 bit-16 bit, 16 bit-32 bit, 32 bit-32 bit. Specifications of some popular microcomputers are as follows,

16-8 bit	8-16 bit	16-32 bit
APPLE IIC	IBM PC	APPLE Macintosh
1 MHz	4.7 MHz	8 MHz

- capabilities for virtual memory. The CPU anticipates information it requires from peripheral memory storage devices and shuttles data to itself to minimize wait time and make the internal memory appear to be of infinite size;
- the programming language used;
- the quality and elegance of software used.

cursor An electronic pointer that indicates to user and computer which information in the video screen is to be addressed

floppy disc A magnetic tape formulated on a disc, which is capable of storing from 140,000 to 1.2 million bytes of memory. The extent of storage depends on the diameter of the disc and the density (packing) of information

front office The physical area staffed by nonphysicians who perform activities that include billing, accounting, word processing and scheduling

hard disc A magnetic storage medium that stores and retrieves information much more quickly than floppy discs. This would be the preferred storage device to handle medical information at the present time. Floppy discs or magnetic tape would still be required to back up hard discs. Some hard discs even have exchangeable discs to more readily expand memory capabilities

internal memory Electronically stored information in semiconductor chips. This form of memory functions as a scratch pad to permit faster accession by the CPU. Storage of information for most 8- and 16-bit machines ranges from 32,000 to 512,000 bytes

language An interface between the computer and user that recognizes and executes instructions given the computer

laser disc An upcoming modality of mass storage that permits information to be optically and permanently stored onto a disc. This product is similar to the compact discs used to play stereo music. When compared with other forms of memory storage, its advantages are large, unerasable quantities of data—some ¼ million pages of data per disc

microcomputer The personal computer with 8 bit-16 bit technology, possessing limited speed and accession of internal memory. Its advantages are low cost and inexpensive and available software. Its primary disadvantages, relative to the minicomputer, are a lack of time-sharing to provide access to internal data bases, ability to handle simultaneous tasks and manipulate large amounts of data and access to sophisticated operating systems. Some of these distinctions are becoming blurred with advances in technology and decreasing costs

mouse A mechanical interface that is moved across a flat surface such as a desk to position a cursor on the video screen to rapidly retrieve information without the use of a typewriter keyboard

operating system A collection of instructions that enables the computer to handle housekeeping chores that supervise the processing of software and all output and input of information

software The instructions listed in a program (script) that are executed by the computer

superbill An itemized statement indicating previous amount owed, current procedures and services rendered and balance outstanding

user-friendly software Programs that interact with a user to provide self-documentation of instructions and commands and ease of operation

video display A television monitor that can display information from the computer

ABBREVIATIONS USED IN TEXT

IBM = International Business Machines, Inc.
MUMPS = Massachusetts General Hospital Utility MultiProgramming System
SOAP = Subjective, Objective, Assessment and Plan

puter record of a patient's visit summarized with two sentences describing each visit, a list of medications and a problem list limited to eight active problems. Furthermore, descriptions of each patient visit were handwritten in subjective-objective-assessment-plan (SOAP) format and were forwarded either as computer formatted or as is to the chart to be filed in shingle fashion (Figure 1). This system, maintaining both a traditional chart and the capability of retrieving electronically stored patient records (limited in scope), cost about $17,000—perhaps less today.

A more sophisticated system, MEDSTAR (a commercial version of COSTAR that uses an operating system called the

Patient encounter → Computer record of past encounters, problem list and medications → handwritten SOAP → word processing → chart

Figure 1.—Principles of the Hawaii system of computerization in a family practice group. SOAP = Subjective, Objective, Assessment and Plan.

Patient encounter → Computer generation of previous HPI, PE, PL, Labs, CXR and ECG and anticipated procedures → handwritten SOAP → Computer entry

Figure 2.—Principles of the Virginia system for a two-person office, using the Massachusetts General Hospital Utility MultiProgramming System. (See Table 3 for abbreviations used in figure.) SOAP = Subjective, Objective, Assessment and Plan.

TABLE 2.—*Attributes of Medical Office Computer Systems*

An itemized patient (super) bill, detailing prior and current charges for medical services, is generated for office-based procedures at the end of each month, billing cycle or office visit.

Automatic completion of insurance forms (some systems telephonically communicate with third-party payers for more rapid payment) is accomplished specifying patient, demographic information, diagnoses, services and procedures rendered, charges and credits.

Relevant information about account activities and balances can also be obtained—that is, it is possible to query accounts by individual, family, day, month or year and ascertain how one's accounts receivables are distributed in terms of outstanding debts versus settled accounts. Data can also be extracted from the computer to generate daily ledgers.

Data reflecting physician activity represent yet another computer capability. This information is relevant to physicians because it permits them to break down income-producing activities by specific services and procedures and judge their individual merits on an economic basis.

TABLE 3.—*Data Base Generated in Virginia System*

Financial status of patient
Problem list (PL)
History of present illness (HPI) and physical examination (PE)
Laboratory and other procedures deemed necessary on a preventative, maintenance basis—prompts user
Laboratory values (Labs)
Summaries of chest x-ray (CXR) findings
Summaries of electrocardiographic (ECG) results
Other tests

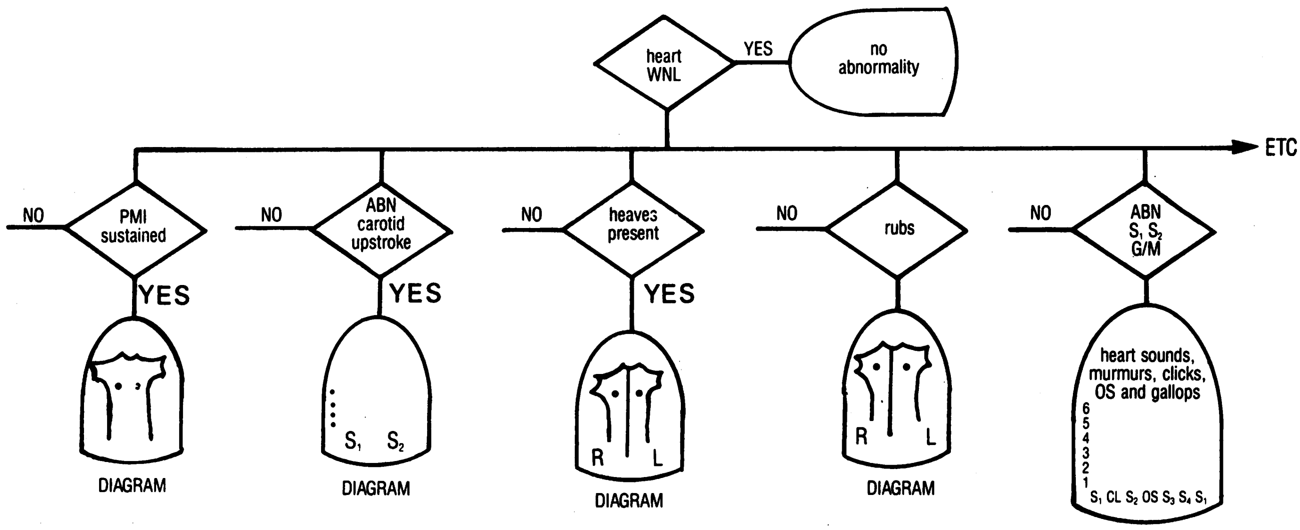

Figure 3.—A flow chart for a cardiac examination. WNL = within normal limits, PMI = point of maximal impulse, ABN = abnormal, G/M = gallop/murmurs, OS = opening snaps, R = right, L = left.

Massachusetts General Hospital Utility MultiProgramming System [MUMPS]), was used by a two-person practice in Virginia, one that came close to realizing a nearly paperless office. A summary of how these physicians interacted with their computer system to generate an integrated data base that describes an office visit is shown in Table 3. At a computer symposium in 1981, Hattick and associates reported that through a computerized chart review, they were able to better achieve health maintenance and to improve efficiency in seeing patients.[3] They stated that they were able to decrease by about 15% the time required to evaluate a case and record impressions in the SOAP format (Figure 2). Automated patient correspondence and generation of patient workups for prospective admissions to hospital were also realized. In 1982, an installed system cost between $18,000 and $30,000.[4]

Reasonable expectations for computers in the near future are indeed tantalizing. Some of these capabilities are discussed below.

Data Entry

Computers can function as repositories of patients' medical records. This has already been accomplished with such systems as MEDSTAR, which can store data representing patients' histories, physical examinations and laboratory reports. Comprehensive electronic medical charting, however, will be limited to only those advanced systems using *user-friendly* software. Apple's new LISA computer, specifically addressing middle-management business needs, nicely shows one company's concept of this term. LISA uses visual equivalents and a cursor directed by a mechanical device known as a mouse (see glossary in Table 1) to select and manipulate data. These capabilities provide an ease of operation necessary to gain physician acceptance of computers. Figure 3 shows how a physician using such concepts might, in the future, interact with a computer to pictorially describe a cardiac examination; the physician would indicate which portions of the examination were normal and which others were abnormal. Figure 4 shows a representation of an examination significant for a grade 2/6 systolic ejection murmur, a split second heart sound (S_2) and an S_3 and S_4 gallop.

Alternatively, in implementing data storage, speech may be used rather than keyboard entry. At the University of California at San Diego, members of the anesthesiology department have been developing a computerized transcription device that recognizes some 150 spoken words to generate a log (K. Davidson, "Operating Room Vocabulary—Doctors May Soon Talk to Computers," *Los Angeles Times,* Sep 15, 1983, p 18). In time, medical information could be directly communicated as speech to a computer. Though medical terminology seems better suited than other types for speech recognition because of the multisyllabled words often used, applications such as medical dictating are still at least a decade away from being implemented.[5]

Laboratory Records

Computers are capable of maintaining longitudinal records of laboratory values with the goals of recognizing trends and notifying health personnel of problems. Laboratory values could be pictorially displayed as a three-dimensional graph consisting of three axes representing specific laboratory values over time for all laboratories, respectively.[6] A lab-

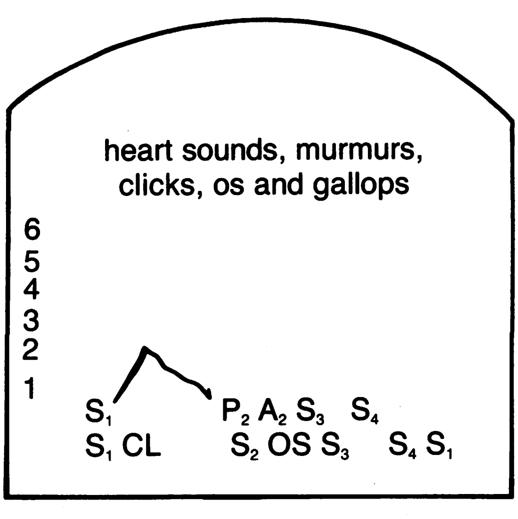

Figure 4.—A pictorial aid for a physical examination. OS = opening snaps, CL = click

oratory value could, for example, be defined as a weight, blood pressure or a potassium value.

Medication and Problem Lists

The ability to retrieve from electronic storage medication lists, problem lists and summaries of office visits enhances physicians' ability to care for their patients. These capabilities would facilitate rapid chart reviews, provide assessment of possible drug interactions, ease the preparation of prescriptions and aid in patient education and cómpliance by issuing relevant information about patients' diseases and their medications.

Consultations

Because computers are good at manipulating large amounts of information, they can offer consultation to a physician concerning a specific patient problem. Of necessity, these large data-based systems require the facilities of fast processing and large amounts of memory, presently limiting the microcomputer's accessibility to such tools (save the use of medical computer services and telecommunications). A group at Stanford University developed an artificial intelligence program to deal with issues of septicemia and meningitis. The program maintains an interactive dialogue with physicians from which a data base is constructed and the appropriate antibiotic regimen is selected, using Bayesian decision theory.[7] In contrast to many other artificial intelligence systems, this program's line of *reasoning* can be elicited to provide insight about how and why an antibiotic was selected. The computer system did as well as attending physicians in infectious diseases during an evaluation of ten challenging cases of meningitis, never failing to recommend the appropriate antibiotic coverage.

Another artificial intelligence program is the INTERNIST-I (CADUCEUS), which evaluated 19 Massachusetts General Hospital case presentations as reported in the 1969 issues of *The New England Journal of Medicine*. The program did well; it correctly identified 17 major diagnoses in contrast to 23 correct diagnoses by the primary physician and 29 by the discussants. The creators of this research tool (R. A. Miller, MD; H. E. Pople, Jr, PhD, and J. D. Myers, MD), however, recognized deficiencies that resulted in reliability problems when applied to the clinical setting. They noted that the program had limitations in the content of its knowledge base—that is, its ability to conceptualize temporally and anatomically and assume a broad overview of a problem, weighing (assigning importance) criteria that form algorithms, assigning causality and attributing specific data to simultaneous disease states.[8]

Continuing Medical Education

Large data bases contained in electronic and magnetic mediums, the increased prevalence of home computers that telephonically communicate and decreasing costs of telecommunications can greatly ease the way we learn and use information. Computers are capable of providing instructive patient management: physicians can be queried by a computer about how they would diagnose and treat patients with medical problems. Managing several cases per month over ten years would appear to provide more educational value through continuous study and would meet with less physician resistance than recertification examinations. The American Medical Association (AMA) and General Telephone and Electronics are developing the AMA/NET, a large data base that offers drug information, differential diagnoses premised on signs and symptoms and the beginnings of a literature base that will eventually be expanded to provide citations and abstracts.[9]

Diagnosis-Related Groups

Virtually all hospitals caring for Medicare patients since October 1, 1984, have been required to codify diagnoses into 467 categories to qualify for prospective payments to achieve cost-containment for the Medicare system (N. Macrae, "Health Care International," *The Economist*, 1984; 291:17-35).[10] Trends indicate that physicians' fees will also be subjected to such controls. If physicians are to substantiate claims made to government agencies and other third-party payers, quality assurance audits will be required. Unless records are computerized, this will be a nearly impossible task. Computers can provide the opportunity to define a new brand of medicine that will seek to balance the need to leave no stone unturned and the cost-health benefit to patients and communities.

Risk Management

Some 35% to 45% of all malpractice claims are rendered indefensible by problems with medical records.[11] Well-organized, legible and complete medical records are important to help convince a jury, if necessary, that a physician's assessment and plan mirror the concern for thoroughness suggested in a patient's chart. Computers can help provide quality records.

Computerized records pose other legal issues. Patients are entitled to request information contained in medical records.[12] Compliance with patients' requests, particularly if numerous in quantity, might well require an electronic means of information retrieval. Inherent in many written records are poor organization, problems of legibility and omissions that lead to errors in patient care. Perhaps rightly so, judges and juries will not tolerate errors based on acts of omission. Norris and Szabo, quoted in a *Journal of the American Medical Association* commentary, indicated that courts may come to expect that computers will be part of the legal standard of medical care.[13]

Confidentiality and Storage of Records

Whether information be present in Daniel Ellsworth's psychiatrist's files or contained on magnetic tape, it will remain accessible and vulnerable to misuse. A range of concepts and devices to protect the confidentiality of patients' records is available. Examples are restricting physical access to a computer, changing passwords frequently and using expensive ciphers that encode information into a near-infinite number of permutations.

Storing and retrieving information presents several problems. Times will arise when access to computer records will not be available because a computer is not functioning. Occasionally, magnetic tape and floppy-disc memory may be altered or lost, presenting authenticity problems and loss of patient records, respectively. Alternatives are microfiche, paper tape/cards and maintaining computer printouts initialed by a physician. An intriguing alternative for the future is offered by laser discs, which optically record upwards of 275,000 pages of unerasable material onto 4.72- or 5.25-inch discs that are anticipated to be very cost competitive (K. Bergheim, L. McGeever, "Lasers Enhance Mass Storage," *Information World,* June 25, 1984; 3:40-45). Last, patients could wear a bracelet containing their entire medical record, which would be updated with each office visit and ensure availability of records.

Purchasing a Computer

I will now conclude with some practical considerations toward the purchase of computer systems. Advice summarized in Table 4 avoided mention of when, from whom and the size of computer system to purchase. These are the most difficult questions. Though it appears that IBM's personal computer has emerged as the industry standard for the microcomputer market, as evidenced by market share and look-alike copies, nothing of the sort can be said for its medical applications. The minicomputer market is even less clear in declaring a leader.

There is a general lack of a universal standard in hardware, let alone in a programming language. This lack of conformity results in diluted resources for developing software and in limited communication between physicians and their machines. The emergency room situation is an example where it might be critical to have access to information from a patient's private physician's computer to provide the proper care.

TABLE 4.—*Advice for Purchasing a Computer*

- Find a reliable dealer who specializes in medical software, offers prompt servicing of equipment and is likely to be staying in business.* A list of installations should be made available to customers. Service contracts on both the hardware and software will be required.
- Shop for software first, then buy your hardware. Software that is written for operating systems such as **UNIX** or **PICK** will provide important freedom—the ability to operate software on any brand of hardware that supports the operating system. Modifications to customize software are very expensive, costing from $35 to $50 per hour of programmer's time. It is important to shop comparatively for desired features. A system should allow for growth. Software needs to be simple to operate, particularly when using temporary office help. Also, consider the comfort of employees when purchasing such equipment. For example, the increased eye strain of some video monitors should be considered.
- Physician comments in the form of paragraphed text (such as a dictated discharge summary) are no substitute for an indexed, well-organized, electronic patient record-retrieval system. These criteria are prerequisites for searching and collating information that will permit data-base management.
- Buy the best quality peripheral devices available. Moving parts on printers and disc drives can break down and cause great aggravation.
- Inquire what provisions have been implemented to prevent employee embezzlement and limit access to confidential information. Audit capabilities will be very important towards achieving this end.
- Selection between a minicomputer and a microcomputer requires a proper definition of a physician-user's needs. Minicomputers, in contrast to microcomputers, offer more hardware features such as passwords, multiple task capabilities, simultaneous users and operating systems that permit more flexible filing of records and manipulating data bases. These distinctions, however, adding a great deal of cost, are becoming less obvious with the increasing technologic advances being implemented within the microcomputer industry.
- Performance guarantees in writing to ensure that the machine and software function as promised are important. Access to the source code in the event of software company default (bankruptcy) to permit easier software modifications is also worthwhile.

*From McCartney[14] and Zimmerman et al.[15]

TABLE 5.—*Computer Options for Practicing Physicians*

- Obtain a system at some cost to run both the front and back office.[4] As more systems of this sort become commercially available, comparison shopping can help physicians to better define their needs.
- Obtain a system that handles the front office and aspects of the back office, recognizing that vendor promises to provide future software advances are not always delivered.
- Defer buying until sufficient hardware and software maturation is achieved, perhaps in one to two years. The disadvantage of this option, however, is that there will be that much more in accumulated records that will need to be converted and entered into the computer.

Perhaps the federal government will provide the lead to encourage programming in MUMPS by its adoption at Veterans Administration Medical Centers across the country. MUMPS handles data in "dynamic (readily changeable), sparse and hierarchical files" well suited to handling medical billing and records.[16] An alternative is American Telephone and Telegraph's UNIX operating system, recently licensed to IBM, that permits portability of software between different brands of hardware that have adopted the *same* version of the UNIX operating system. A third choice, featuring not only portability but excellent data-base-management capabilities as well, is Dickpick's PICK system (R. Cook, "Operating Systems," *Popular Computing,* Aug 1984; 3:111-148). Confounded physicians are left with three options, and these are summarized in Table 5.

My appraisal of the present market is that, because of the costs and sophisticated programming required to implement comprehensive electronic medical charting, the capabilities of most commercial computer systems are limited to front office applications. I expect these obstacles to be better addressed with the decreasing costs of computers and memory and more simplified interfacing of the computer to users. A market that in the near future will exceed hundreds of millions of dollars should provide the commercial incentive to rectify these problems.

REFERENCES

1. Halenar JF: A service bureau may still be your best answer. Med Econ 1982; 52:124-142
2. Farrel DL, Worthy RM: Implementation of a computer-assisted medical record system in the family practice office. Hawaii Med J 1982; 41:90-93
3. Hattwick MA, Hart RJ, Zuckerman A, et al: Using the information tool to improve preventative medical care—Proceedings of the 5th Annual Symposium on Computer Applications in Medical Care. IEEE Frontiers Eng Comput Health Care 1981, pp 182-186
4. Harsham P: Programming: Do it your own way. Med Econ 1982; 59:161-171
5. Entine S, Entine L: Talk is getting cheap. MD Computing 1984; 1:66-78
6. Friedman E: Digital doctors: Physicians are warming up to computers with surprising results. Hospitals 1983; 57:91-98
7. Yu V, Lawrence MF, Sharon MW, et al: Antimicrobial selection by a computer. JAMA 1979; 242:1279-1282
8. Miller R, Pople HE Jr, Myers JD: INTERNIST-I, an experimental computer-based diagnostic consultant for general internal medicine. N Engl J Med 1982; 307:468-476
9. Storey PB: Computers are the key. Internist 1983 Oct; 24:10-12
10. Attention turns to DRGs for doctors. Internist's Intercom 1983; 7#9 (pamphlet)
11. Rasinski D: Risk management in practice. Am Soc Intern Med 1983; 353:1-8
12. Hiller M: Computers, medical records, and the right to privacy. J Health Polit Policy Law 1981; 6:463-487
13. Levinson D: Information, computers, and clinical practice. JAMA 1983; 249:607-609
14. McCartney L: How to buy just what you need. Med Econ 1982 Nov; 59:38-75
15. Zimmerman J, Boxerman SB, Rector AL: Are minicomputers appropriate for your practice? JAMA 1979; 242:1887-1889
16. Zimmerman J, Rothmeir J: History and future of MUMPS in medical computing. Med Information 1979; 4:5-11